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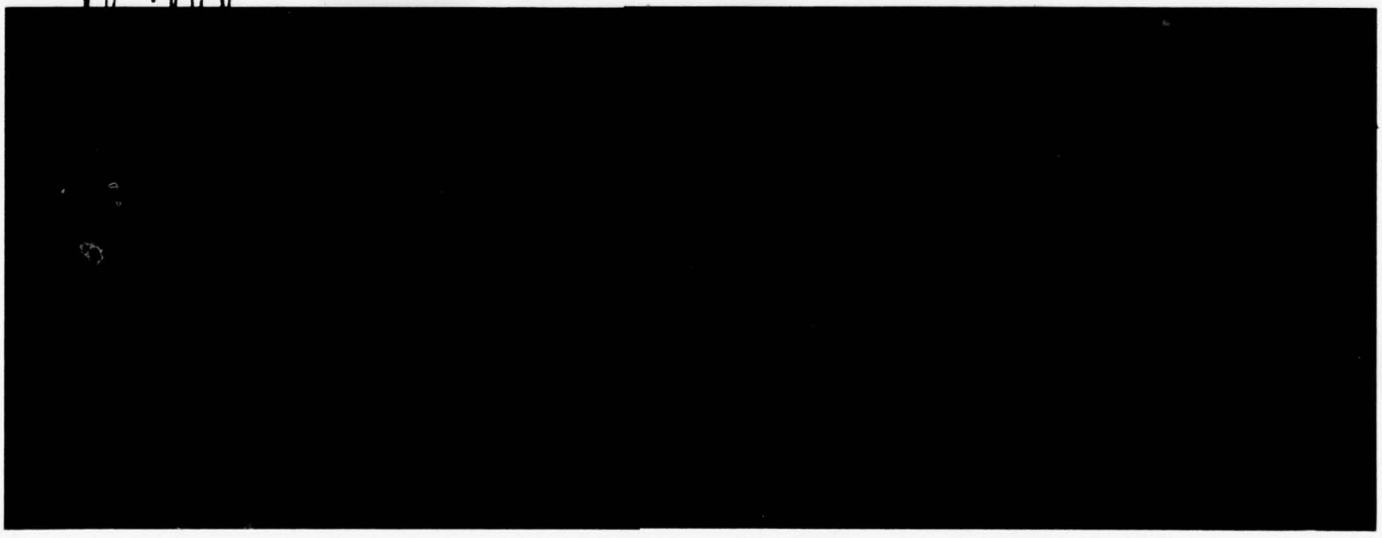
PHASE II FINAL REPORT

ECONOMIC ANALYSIS OF SELECTED TEST MEASUREMENT AND DIAGNOSTIC EQUIPMENT FROM THE U. S. ARMY COMMUNICATIONS COMMAND PREFERRED ITEMS LIST

November 1974

Prepared for
THE U. S. ARMY ELECTRONICS COMMAND
FORT MONMOUTH, NEW JERSEY
and
THE U. S. ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA, ARIZONA
under Contract DAEA18-72-A-0005

ARINC RESEARCH CORPORATION



ECONOMIC ANALYSIS OF SELECTED TEST MEASUREMENT AND DIAGNOSTIC EQUIPMENT FROM THE U.S. ARMY COMMUNICATIONS COMMAND PREFERRED ITEMS LIST.

PHASE II FINAL REPORT on Phase 2,

November 1974

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The U.S. Army Electronics Command
Ft. Monmouth, New Jersey; and
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Ft. Huachuca, Arizona

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FOREWORD

ARINC Research Corporation is conducting an economic analysis of selected Test Measurement and Diagnostic Equipment (TMDE) from the U.S. Army Communications Command (USACC) Preferred Items List (PIL) for the U.S. Army Electronics Command, Fort Monmouth and USACC, Fort Huachuca. This report presents the results of Phase II of the analysis, which was to determine the availability and quality of the data required to conduct the economic analysis of the subject TMDE. Phase I, completed and reported upon in August 1974, encompassed the development of a life cycle cost estimation methodology and the selection of three PIL items for detailed economic analysis.

The format of this report is in accordance with the contract specifications.

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Section 1

INTRODUCTION, SUMMARY AND CONCLUSIONS

1.1 INTRODUCTION

This report presents the results of a two-month study for the U.S. Army Electronics Command (USAECOM), Ft. Monmouth, New Jersey, and the U.S. Army Communications Command (USACC), Ft. Huachuca, Arizona. The study represents the second phase of an anticipated five-phase program to evaluate the overall cost effectiveness of standardizing Test Measurement and Diagnostic Equipment (TMDE) of the USACC Preferred Items List (PIL).

The five proposed phases of the program are:

Phase I — Development of a TMDE life cycle cost (LCC) estimation methodology and selection of three PIL TMDE for detailed economic analysis.

Phase II — Determination of the availability of data required to conduct the economic analysis of the three selected TMDE.

Phase III — Conduct of the economic analysis of the selected TMDE.

Phase IV — Development of a methodology for evaluating the economic impact of the complete PIL, based upon the results of Phases I, II, and III.

Phase V — Evaluation of the economic impact of the complete PIL, using the methodology developed during Phase IV.

Due to uncertainties concerning availability of the data required for the economic analysis, USAECOM and ARINC Research agreed that Phases I and II would first be performed; that the scope of Phases III and IV would be defined at the conclusion of Phase II; and that the scope of Phase V would be defined after completion of Phase IV.

Performance of this work by ARINC Research Corporation was authorized on 28 June 1974 by Contract DAEA18-72-A-0005, a basic ordering agreement with USACC. The four-month effort comprising Phases I and II was initiated under delivery order 0006, issued by Procurement Division, Headquarters, Ft. Huachuca. The present report describes the work performed under Phase II, together with a recapitulation of the tasks performed during Phase I.

1.1.1 Review of Phase I Activity

Phase I of the study was completed during August 1974 and described in a final report delivered to USAECOM.* Performed during Phase I were four major tasks:

(1) Development of a detailed procedural outline of the LCC estimation methodology to be used in estimating the cost savings anticipated from standardization of the three selected TMDE.

(2) Development of detailed criteria for selection of the three TMDE to be evaluated in Phase III.

(3) Selection of the three TMDE for detailed economic analysis in accordance with the selection criteria developed in Task 2.

(4) Preparation of a Phase I final report to document the results of Tasks 1 through 3.

During Task 1, a detailed procedural outline of the LCC estimation methodology was developed. The methodology was designed to compare the LCC of an item of TMDE with the cost of continuing to support all functionally similar TMDE currently in the USACC inventory that can potentially be phased out of the inventory.

Applicable DoD and Department of the Army (DA) documents were reviewed to specifically define the LCC requirements that must be satisfied. The basic source documents included Electronics Command Pamphlet ECOMP 11-4, Volume 7, Army Programs Cost Estimating Guide; AR-37-13, Army Regulation for Economic Analysis and Program Evaluation of Resource Management; and Paragraph C of Armed Services Procurement Regulation ASPR 3-213.2, Technical Equipment Requiring Standardization and Interchangeability of Parts. All assumptions and constraints that will affect the LCC analysis were identified and defined, as were all LCC elements that must be considered in the analysis.

Potential sources of data for the economic analysis were identified. These sources include USAECOM, the U.S. Army Communications Systems Agency (USACSA), and the Department of the Army (DA) Comptroller's Office, Fort Monmouth; USACC, Forth Huachuca; the U.S. Army Metrology and Calibration Center (USAMMC), Redstone Arsenal, Alabama; the U.S. Army Maintenance Management Center, Lexington, Kentucky; and the U.S. Army Training and Doctrine Command (TRADOC), Fort Gordon, Georgia.

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*ARINC Research Corporation, Phase I Final Report: Economic Analysis of Selected Test Measurement and Diagnostic Equipment from the U.S. Army Communications Command Preferred Items List, Publication 1072-01-1-1316, August 1974.

During Task 2, detailed criteria were developed for the selection of the three TMDE that will be evaluated in Phase III. The criteria include such items as quantity of equipment deployed, equipment operational and functional characteristics, and the probable availability of equipment data.

Task 3 was the selection of the three TMDE for detailed economic analysis. In accordance with the criteria developed in Task 2, several TMDE were selected and graded as to desirability. Final selection of the three items was coordinated with USAECOM and USACC during a steering committee meeting in September 1974. The USACC "TMDE Cross Reference List" and "Command Density Report" were used to identify the TMDE that can potentially be removed from the inventory.

A Phase I final report was prepared during Task 4 to document the results of Tasks 1 through 3. The contents of this report were reviewed during the above-mentioned steering committee meeting.

1.2 OVERVIEW OF WORK PERFORMED DURING PHASE II

Activities performed under Phase II and described in this report consisted of six major tasks:

(1) Development of survey forms and other documentation required to collect the data identified during Phase I, and of a detailed schedule for visiting all relevant Army facilities.

(2) Conduct of the survey required to determine the nature and availability of life cycle cost data for the economic analysis.

(3) Evaluation of the results of the data collection activity to determine the adequacy of available data.

(4) Determination of the most appropriate means of implementing the LCC estimation methodology for the three TMDE selected for analysis.

(5) Preparation of a Phase II final report to document the results of Tasks 1 through 4.

(6) Estimation of the resources required to conduct Phase III of the economic analysis.

During Task 1, survey forms (questionnaires) were prepared to aid in the determination of the nature and availability of data identified during Phase I. These forms covered the major cost categories of Research and Development, Investment Nonrecurring, Investment Recurring, and Operation; along with the appropriate cost elements of training, hardware, documentation, consumables, transportation, inventory management, installation, personnel, and disposal. The forms were structured to permit the identification of data for each of the three selected PIL TMDE, and all of the potential non-PIL replacements established during Task 3 of Phase I.

A visitation schedule was prepared for the data survey, to include all sources identified in Task 1 of Phase I. Each agency was contacted to establish a firm date for the interviews.

Task 2 was the data survey. A representative of ARINC Research visited the Army activities referred to in 1.1.1 to interview cognizant technical and management personnel concerning the data needed for the TMDE economic analysis. Further, to take maximum advantage of the visits to these Army sites, efforts were made to actually collect as much data as possible in anticipation of this required activity during Phase III. The data collection task scheduled for that phase has thus been minimized. Interviews were held with cognizant technical and management personnel at each location.

During Task 3, the information obtained from the data survey was evaluated as to its suitability (quality and quantity) for application to the LCC methodology developed during Phase I. Where a data item was found inadequate, in terms of either quality, quantity, or availability, consideration was given to using alternative data. Alternatives include the use of:

(1) Average rather than specific costs;

(2) Cost of similar equipments, when cost was not available for a specific TMDE;

(3) Cost estimating relationships (CERs) developed from data provided by the Army Comptrollers Office; and

(4) Estimates of Army management and engineering personnel having wide experience in TMDE.

The product of Task 3 was a revised methodology for determining the cost of training, hardware, personnel, installation, consumables, inventory management, documentation, disposal, and transportation for the three selected PIL and potential non-PIL TMDE to be replaced.

During Task 4, a determination was made of the most appropriate means of implementing the life cycle cost methodology developed in Phase I and refined in Tasks 1-3 of Phase II. Efforts were made to identify all Army cost models that might be applicable, including the Generalized Electronics Maintenance Model (GEMM). Consideration was also given to the development of a computation program specifically for the Phase III analysis.

A final report was prepared during Task 5 to document the results of the Phase II tasks. The contents of this report will be reviewed during the steering committee meeting in November 1974.

A statement of work was prepared under Task 6 defining the technical approach to and necessary resources for determining the cost effectiveness of standardizing the PIL TMDE items selected during Phase I, through replacement of the non-PIL TMDE items. The statement of work was delivered under separate cover to USAECOM for review.

It was originally intended that a statement of work be prepared at the same time for Phase IV; however, it became apparent during Phase II that the scope of activities could be better defined through knowledge of the results of the Phase III economic analysis. Therefore a statement of work will be prepared for Phase IV prior to the completion of Phase III and a statement of work will be prepared for Phase V prior to completion of Phase IV.

1.3 REPORT ORGANIZATION

This report has been prepared in accordance with the format specified in data item A002 of the Contract Data Requirements List (DD Form 1423), dated 10 June 1974. The report consists of two sections. Section 1 presents an introduction, overview of work performed, and summary and conclusions. Section 2 describes in detail the technical approach used to perform all tasks. Each task in Phase II is addressed separately, in conformity with the organization of the summary and conclusions in 1.4.

1.4 SUMMARY AND CONCLUSIONS

The activities performed under Phase II of the TMDE economic analysis resulted in the development of the required data elements and a recommended technique for implementation of the LCC methodology. The methodology will be used during Phase III to determine the total life cycle cost of the selected TMDE, and will also support the activities of Phases IV and V. These latter phases involve the development and application of a methodology for determining the economic impact of standardization of the complete PIL.

Results of the Phase II tasks are summarized in 1.4.1 through 1.4.6. Detailed results are presented in Section 2.

1.4.1 Task 1 – Development of Survey Documentation

The survey forms and questionnaires necessary to identify the availability and quality of the LCC data were prepared during Task 1.

1.4.2 Task 2 – Conduct of Data Survey

A data survey was conducted to determine the availability and quality of LCC data for supporting the TMDE economic analysis. The personnel interviewed indicated the availability of (and in many instances provided) a wide variety and substantial quantity of relevant information, for example:

(1) Printouts from computer programs designed to collect and summarize data on TMDE

(2) Specific information on manhours spent for calibrating and maintaining TMDE

(3) Data on the quantity of the MOS (military occupation specialty) classifications that operate and maintain TMDE

(4) Course and cost requirements for the training of the identified MOS

(5) Cost of TMDE hardware and selected accessories

(6) Details on documentation (such as technical manuals) needed for calibration and operation

(7) Authenticated values (such as cost factors) for establishing CERs.

1.4.3 Task 3 – Evaluation of Data Survey

Results of the data survey were evaluated in Task 3 relative to the availability of the data needed for the TMDE economic analysis. It was determined that:

(1) Data for the cost elements of training, personnel, hardware, documentation, disposal and installation were adequately identified and are suitable for use in the determination of life cycle costs of both PIL and non-PIL TMDE. Only minor changes and estimations were necessary to adapt the data to the Phase III economic analysis. This was done by modifying certain equations developed during Phase I, and through the use of engineering estimates. Full details on this process are given in Section 2 for Tasks 2 and 3.

(2) The data for consumables, inventory management, and transportation were not considered suitable for use in the Phase III economic analysis. The major reasons were the unavailability of information on the consumables for specific TMDE, and the extensive quantity of data that would have to be reviewed and collected for use in the equations developed for inventory management and transportation under the Phase I methodology.

Because of the difficulties noted in (2), above, cost estimating relationships were developed to permit retention of the cost elements in the Phase III economic analysis. These CERs were based upon information provided by the DA Comptrollers Office at Ft. Monmouth for use in estimating the costs of electronic equipment. Full details on the development of these CERs are given in Section 2 under Task 3.

1.4.4 Task 4 – Determination of Implementation Technique for LCC Methodology

Various means of implementing the LCC methodology during Phase III were evaluated. Efforts were made to identify an available cost model that could specifically address an economic analysis of TMDE, but were unsuccessful. The Army Generalized Electronics Maintenance Model, for example, does not provide for determining certain critical cost elements such as equipment calibration, nor does it address the logistics concepts for the Area Maintenance and Supply Facility (AMSF) used for TMDE repair by USACC in the Pacific and European theaters.

It was decided therefore that the implementation of the LCC methodology could be best accomplished through the development of a computation program based on the equations developed for the cost elements during Task 3. In essence, the recommended program will perform the economic analysis in a manner similar to that of a manual-calculation process. The major difference is that the computerized technique will require significantly less calculation time.

1.4.5 Task 5 – Preparation of Phase II Final Report

Task 5 consisted of the preparation of the Phase II final report documenting the activities of Task 1 through 4.

1.4.6 Task 6 – Preparation of Statement of Work for Phase III

A statement of work describing the tasks required to perform the economic analysis of Phase III was prepared by ARINC Research and forwarded under separate cover.

Section 2

DETAILED RESULTS OF TASKS PERFORMED

Six major tasks were performed during Phase II of the TMDE economic analysis. Tasks 1 through 4 defined the nature and availability of LCC data for the cost elements of training, hardware, personnel, transportation, consumables, inventory management, documentation, installation, and disposal. Task 5 was the preparation of a final report documenting the results of Tasks 1 through 4. Task 6 was the preparation of a statement of work for the Phase III economic analysis on the three selected PIL TMDE and the non-PIL TMDE they can replace. The statement of work was delivered to USAECOM under separate cover.

Results of Tasks 1 through 4 are discussed in 2.1 through 2.4.

2.1 TASK 1 – DEVELOPMENT OF DOCUMENTATION FOR DATA SURVEY

Task 1 was to develop the documentation to support the data survey, and comprised the activities discussed below.

2.1.1 Definition of Life Cycle Cost Elements of TMDE

For purposes of this economic analysis, the life cycle of the TMDE was defined during the Phase I study as beginning with the acquisition of hardware and ending with the disposal of the item after 10 years of operation. In cost terms, the life cycle can be further defined to encompass three categories: Investment Nonrecurring, Investment Recurring, and Operating. Elements of these categories are training, transportation, hardware, installation, personnel, consumables, inventory management, support equipment, documentation, and disposal. The cost of support equipment was eliminated from consideration in this study since it was determined to be a sunk cost.

2.1.2 Data Requirements for Life Cycle Cost Elements

Life cycle costs for each of the nine cost elements mentioned in 2.1.1 can be determined, if the proper input data are provided, by utilizing the LCC estimation methodology described in the Phase I report. Necessary input data for the cost elements were defined as discussed below.

The data identified during Phase I formed the basis for the content of the Phase II questionnaires. The data and their related cost elements are reviewed in 2.1.2.1 through 2.1.2.9.

2.1.2.1 Training

Training cost is that of training personnel to operate and maintain the TMDE. The operating costs are incurred in support of the C-E sites, while the maintenance expenditures are associated with repair and A- and C-level calibration. Two other expenses, that of instructor and initial training, may also be part of the total training cost during the life cycle of TMDE.

The data requirements for establishing training cost are:

(1) MOS classification:

- (a) Performing A-level calibration
- (b) Performing C-level calibration
- (c) Performing repair
- (d) Operating the equipment

(2) Cost of training one MOS for:

- (a) A-level calibration
- (b) C-level calibration
- (c) Repair
- (d) Operation

(3) Total number of MOS:

- (a) Performing A-level calibration
- (b) Performing C-level calibration
- (c) Performing repair
- (d) Operating the equipment

(4) Turnover rate of MOS:

- (a) Performing A-level calibration
- (b) Performing C-level calibration
- (c) Performing repair
- (d) Operating the equipment

(5) Quantity of TMDE at each C-E site

(6) Total number of sites with TMDE

(7) Life cycle of TMDE

2.1.2.2 Hardware

Hardware cost includes the unit price of the TMDE, documentation (prepared manuals), accessories, and quality assurance testing. The data requirements for establishing hardware cost are:

(1) Unit price of TMDE

(2) Cost of manuals obtained with TMDE

(3) Cost of accessories

(4) Expenses incurred in test and evaluation of TMDE

2.1.2.3 Personnel

Personnel cost includes the personnel expenses associated with the operation and maintenance of TMDE. The maintenance expenses are for A- and C-level calibration and repair of the equipment. Data requirements for establishing personnel cost are:

(1) MOS classification:

  (a) Performing A-level calibration

  (b) Performing C-level calibration

  (c) Performing repair

  (d) Operating the equipment

(2) Annual or hourly cost of MOS:

  (a) Performing A-level calibration

  (b) Performing C-level calibration

  (c) Performing repair

  (d) Operating the equipment

(3) Time spent annually by each MOS:

  (a) Performing A-level calibration

  (b) Performing C-level calibration

  (c) Performing repair

  (d) Operating the equipment

(4) Quantity of each TMDE:

  (a) At each C-E site

  (b) Maintained at each shop

(5) Total quantity of sites and shops

(6) Annual maintenance manhours of each TMDE

(7) MTTR of each TMDE

(8) MTBF of each TMDE

(9) Operating hours per year of:

(a) Each TMDE

(b) Each C-E site

(c) Each maintenance shop

2.1.2.4 Transportation

Transportation cost includes the expenses for first-destination and maintenance transportation. Data requirements for establishing transportation cost are:

(1) Location of:

(a) Each C-E site

(b) Each maintenance shop

(2) Distance in miles of C-E site from each:

(a) First-shipment location (contractor)

(b) AMSF or designated maintenance shop

(3) Weight of TMDE

(4) Location to which TMDE is first transported (from contractor)

(5) Number of times TMDE is sent to repair per year

(6) MOS classification performing packaging operation for transportation

(7) Cost per year or hour of MOS performing packaging

(8) Cost of packaging material per shipment

(9) Shipping cost per pound-mile.

2.1.2.5 Consumables

The cost element of consumables includes the expenses incurred for stockage materials to maintain the TMDE in an operating condition. Data requirements for establishing consumables cost are:

(1) Quantity of each stockage item required by each TMDE per year

(2) MTBF of each stockage item

(3) Cost of each stockage item

(4) MTTR of each repairable stockage item

(5) Requisition time for each stockage item

(6) Procurement lead time for each repairable stockage item

(7) Attrition factor for loss of each stockage item

(8) Probability of each stockage item being available for a maintenance action

(9) MTBF of each TMDE

(10) MTTR of each TMDE

(11) Initial issue:

(a) Stockage type and quantity

(b) Stockage cost

(c) Stockage demand

(12) Number of stocking periods for each maintenance facility

(13) Quantity of maintenance shops repairing each TMDE

(14) Total number of TMDE repaired at each maintenance shop

2.1.2.6 Inventory Management

Inventory management cost includes the expenses of introducing and holding stockage for TMDE maintenance actions. Data requirements for establishing inventory management cost are:

(1) Initial stockage:

(a) Allocation quantity for each TMDE

(b) Cost of each stockage item

(2) Reorder stockage:

(a) Quantity allocated for each TMDE

(b) Cost of each stockage item

(c) Ordering frequency

(3) Inventory factor for each TMDE

2.1.2.7 Documentation

Documentation cost includes the expenses of preparing, publishing, and distributing technical manuals for operation, maintenance, calibration, and spares. This cost element does not account for already-issued manuals, such as from a contractor; or documentation made available with the commercial, off-the-shelf TMDE

procurements. That subelement is part of the hardware cost (see item 2 of 2.1.2.2). Data requirements for establishing documentation cost are:

(1) Type of existing documentation for each TMDE for:

(a) Calibration

(b) Operation

(c) Maintenance

(d) Spares (Repair Parts Spares and Tool Lists, or RPSTL)

(2) Number of pages in each document for each TMDE

(3) Cost per page of each document

2.1.2.8 Installation

Installation cost includes the expenses incurred in implementing the TMDE at a C-E site. Data requirements for establishing installation cost are:

(1) Cost of fixtures or carts to install and/or move TMDE

(2) MOS classification installing TMDE

(3) Annual cost of MOS installing TMDE

(4) Time spent by MOS installing TMDE

2.1.2.9 Disposal

Disposal cost is that incurred in removing the TMDE from the force structure at the end of its life cycle; but realizing as an asset any monies from the sale of TMDE at the end of life. Data requirements for disposal are:

(1) Time spent by MOS to remove TMDE from operation

(2) Annual or hourly cost of MOS removing TMDE

(3) Expense incurred in transporting TMDE from site to disposal area

(4) Expense incurred to store TMDE in preparation of disposal action

(5) Assets realized from sale of TMDE

2.1.3 Preparation of Data Forms

Forms were prepared to account for all data items described in 2.1.1. These forms were structured as questionnaires on the specific cost elements for each TMDE.

2.1.4 Development of the Schedule and Contacts for the Data Survey

The various agencies selected as the most valid sources of data for the economic analysis were contacted to establish a suitable visitation schedule for

the survey. The agencies selected for the survey and their location are as follows:

(1) U.S. Army Communications Command (USACC) Fort Huachuca, Arizona

(2) U.S. Army Metrology and Calibration Center (USAMCC) Redstone Arsenal, Alabama

(3) U.S. Army Maintenance Management Center (USAMMC) Lexington, Kentucky

(4) U.S. Army Electronics Command (USAECOM), U.S. Army Communications Systems Agency (USACSA) and the Department of the Army (DA) Comptroller's Office, Fort Monmouth, New Jersey

(5) U.S. Army Training and Doctrine Command (TRADOC) Fort Gordon, Georgia

An ARINC Research representative visited each of these activities during September 1974 to identify and collect the life cycle cost data defined in 2.1.2.

2.2 TASK 2 – CONDUCT OF DATA SURVEY

A survey was conducted to identify the availability, as well as the quantity and quality, of the data necessary to perform the TMDE economic analysis. Where data were found to be available, their origins and characteristics are described in the following sections. In the absence of specific data items, the approach to seeking best estimates is noted.

Results of the data survey are summarized in matrix form in Appendix A. For the three selected TMDE and the TMDE they may replace, and for each cost element defined in 2.1, the matrix indicates the availability of specific types of data needed for the economic analysis.

2.2.1 Training Cost Data

2.2.1.1 MOS Classifications

MOS classifications performing calibration, operation, and repair of TMDE were identified from AR611-201, Personnel Selection and Classification, and from discussions with cognizant personnel at the U.S. Army Materiel Command (USAMC), USAMMC, USAMCC, USAECOM, USACC, USACSA, and TRADOC. The MOS performing the various functions are:

Function	MOS
A-level calibration	35H
C-level calibration and repair	35B 30
TMDE repair	35B 20
TMDE operation	26L, 31, 32, and 34 series; skill levels 10, 20 and 30

2.2.1.2 Training Expenses

Training expenses can be obtained for MOS classifications from the Military Occupational Specialty Training Cost Book, May 1974, Directorate of Cost Analysis Office, Comptroller of the Army. The costs are average weighted values that include both formal, OJT, and instructor training expenses; and cover the overhead, G&A expenses related to the training activity, and expenses incurred for each MOS attending the course at the Signal Corps School. No separate data were identified for initial training or instructor training.

2.2.1.3 Training Time for Specific TMDE

The amount of time spent in MOS training for the calibration and repair of TMDE is not identifiable as a specific data item. The reason is that the MOS performing these functions are trained on a group of equipment that represent the highest density in the Army inventory. For a specific TMDE, the best means of estimating training time for calibration and repair is to use a proportion of the percent of the total quantity of TMDE that the specific type represents.

Since operating personnel are trained primarily to operate C-E end-items, they spend very little time on training to operate TMDE. Most of the operator training for TMDE is done as OJT. Estimates provided by USACC and USAECOM indicate that less than 10% of the training time is on TMDE. The training time for operating TMDE can therefore be estimated using 1) the 10% factor, and 2) the ratio of specific TMDE to the total quantity of TMDE in USACC.

2.2.1.4 Total Number of MOS

The number of MOS performing TMDE calibration, operation, and maintenance at the sites and shops is identified in the tables of distribution and allowances (TDAs) and tables of organization and equipment (TOEs) for each unit identification code (UIC). The total number of each MOS can be derived by reviewing each document and summing the amounts noted. Data sources are USACC and USAECOM records on UIC sites.

2.2.1.5 Turnover Rate

The MOS turnover rate can be obtained from the ECOMP 11-4 publication (see reference, 1.1.1) from the DA Comptrollers Office at Fort Monmouth.

2.2.1.6 Total Quality of TMDE at Each Site

The quantity of TMDE at each C-E site, and the total number of sites with specific TMDE, are listed in TMDE MIP reports issued by USACC.

2.2.1.7 Life Cycle of TMDE

The life cycle of TMDE was established by USAECOM as 10 years.

2.2.2 Hardware Cost Data

2.2.2.1 Cost of TMDE Hardware

Unit prices for each PIL and non-PIL TMDE can be obtained from SB700-20, Army Adopted/Other Items Selected for Authorization/List of Reportable Items; CCP700-20, List of Non-Adopted Commercial Items of Equipment; and/or manufacturer's catalogs. The identified data include the cost of accessories such as carrying cases and other special items obtained with the TMDE to make it operational at the C-E sites.

2.2.2.2 Cost of Software (Manuals)

No specific data were identified for the cost of the manuals obtained with each TMDE. Cognizant USACC and USAECOM personnel estimate that the average cost of maintenance and calibration manuals is in the range of $10 to $25 each, while the operating manual is normally supplied by the contractor at no additional cost.

2.2.2.3 Cost of Testing

No data pertaining to the cost of initial testing of TMDE could be obtained. It was determined that the only initial testing performed on TMDE is visual examination and initial calibration which is performed when the equipment is received at the AMSF. The cost of this initial testing will be accounted for in the Phase III economic analysis as part of the calibration cost.

2.2.3 Personnel Cost Data

2.2.3.1 MOS Classifications

The MOS classifications performing the functions of operation, maintenance, and calibration are identified as discussed under training cost (see 2.2.1.1).

2.2.3.2 Cost of MOS

Data can be obtained from the DA Comptroller at Fort Monmouth for use in determining average hourly costs of MOS. These costs per maintenance manhour for C-E equipments are $5.09 for direct labor only; $6.16 for direct and supervisory labor; and $6.91 direct labor, support, G&A, and overhead cost.

2.2.3.3 Time Spent to Perform Calibration

The amount of time spent per calibration cycle for each TMDE can be obtained from records maintained by the Army Metrology and Calibration Center. The data include both A- and C-level calibration.

2.2.3.4 Repair Time and Failure Rates

An effort was made to obtain MTBF and MTTR values for each TMDE type. Annual maintenance manhours can be derived from this information. Sources of information on MTBF and MTTR are DA Pamphlet 700-21, TMDE Register; and TOE Manpower Authorization Criteria (MACRIT) data files. An attempt will be made to estimate data items not in these sources from values obtained from the contractor for a specific TMDE.

2.2.3.5 Operating Hours

No documented information was identified on the operating hours of TMDE. Estimates based on engineering judgment indicate a typical operating time of 1 hour per 24-hour period, with a maximum average of twice that value. These estimates were made by personnel at USACC, USAECOM, and USACSA.

2.2.3.6 Quantity of TMDE at Sites and Shops

The quantity of TMDE located at each site and maintenance shop was discussed under the cost element of training (see 2.2.1.6). The quantity of shops and sites for each TMDE can be derived from this data.

2.2.3.7 Operating Hours for C-E Sites

Most C-E sites operate 24 hours per day for 365 days a year. Only a limited number operate for 8 hours periods for 360 days a year. Operating schedules are obtainable from USACC and USAECOM.

2.2.3.8 Operating Hours for Maintenance Shops

According to USACC and USAECOM personnel, the typical operating time for AMSF and CONUS shops is 8 hours per day, 5 days per week, 48 weeks per year.

2.2.4 Transportation Cost Data

2.2.4.1 Distance to C-E Sites and Shops

Documented data are not available on mileage that TMDE are shipped for first-destination and subsequent repair to/from each C-E site and maintenance shop. The mileage can be determined from maps, but this method would be very time-consuming (there are some 1,500 C-E sites).

2.2.4.2 First Destination of TMDE

Estimated values for use in determining both first-destination and maintenance transportation costs appear in the previously referenced ECOMP 11-4, available from the DA comptroller. This information was also identified as part of a projected TMDE plan developed by USACC for PIL TMDE. However, data retrieval from that source would be a lengthy process.

2.2.4.3 MOS Classification and Cost

According to cognizant USACC personnel, no MOS designation exists for the function of packaging TMDE for maintenance shipments. Rather, on-site crew personnel often perform this activity as part of their normal duties.

2.2.4.4 Packaging Costs

No data were identified for the cost of packaging TMDE material or for the shipping rate per pound per mile.

2.2.5 Consumables Cost Data

2.2.5.1 Stockage Requirements for Each TMDE

Some portions of the LCC data for the cost element of consumables were not readily identifiable. One difficulty noted was that no initial provisioning, reorder stockage, or replacement stockage has been established for the PIL or non-PIL TMDE to be evaluated in this study. The primary reason for this situation is that the current density of TMDE in USACC operation is too low to warrant such a stockage policy. Instead, stockage is in accordance with the Army's "Secondary Items Stockage Concept". Under that concept, items that have at least three recurring demands every 360 days are included in the Federal Stock Supply as FSN's. If the demand becomes less, the item is removed from the Federal Stock Supply. Because of this stockage policy, it is difficult if not impossible to identify the spares associated with any one TMDE. Hence little or no data exist for determining the specific quantity and type of stock used by the TMDE during a life cycle.

Another problem noted during the data survey for consumables is that the data on those TMDE (such as PIL TMDE), which upon standardization might become of sufficient density to warrant initial provisioning and reorder stockage are far too extensive and complex to obtain. In situations where a RPSTL is available, it would be necessary to expend considerable manhours to identify each stock item by cost, type, quantity, MTBF, and repairability. Where a RPSTL does not exist, it would be necessary to review the circuit diagrams for a specific TMDE and spend considerable time extracting the stockage listings.

For these reasons, it is more practical to estimate from historical data the amount of consumables required per year for a TMDE. Estimated values from studies of the Army and other organizations indicate the percentage of consumables may vary from 5 to 20% of the unit price of the hardware. An average value of 12.5% for consumables is recommended for the Phase III economic analysis.

2.2.6 Inventory Management Cost Data

No data were identified for inventory management costs for the same reasons as noted in 2.2.5 for consumables. Estimates from the DA Comptroller at Fort Monmouth are that the average cost of introducing an item into the inventory is $480; and holding costs are at 23% of the unit price of the hardware for each year of the life cycle.

2.2.7 Documentation Cost Data

2.2.7.1 Documentation for Calibration

Calibration documentation for TMDE can be obtained from TB 48-180, Calibration Requirements for the Maintenance of Army Material.

2.2.7.2 Documentation for Operation and Maintenance

Documentation on TMDE operation and maintenance include both DA and contractor publications, identifiable by reviewing DA Pamphlet 310-4, Index of Technical Manuals: Technical Bulletins, Supply Manuals (Type 7.8, and 8), Supply Bulletin and Lubrication Orders.

2.2.7.3 Documentation for RPSTL

The RPSTLs for TMDE were identified as part of the maintenance manuals, and therefore will be costed with maintenance documentation.

The quantity of parts on the RPSTL for each TMDE can be determined by reviewing the TMs for each equipment. This is a time-consuming process and best addressed by averaging the values for the three PIL and three non-PIL TMDE to be considered in the economic analysis.

2.2.7.4 Quantity of Pages per Document

The quantity of pages in documents published for every TMDE can be identified by a page count. However, since this effort is time consuming, average values based upon the quantity of pages in the publications for the three PIL and three counterpart non-PIL TMDE would be more practical.

2.2.7.5 Cost of Documentation per Page

According to information obtained from the DA Comptroller at Fort Monmouth, the cost of preparing and publishing a technical manual is $74.27 per page. Data from the Publication Office of the U.S. Army Materiel Command indicates an even higher cost: $200 to $300 per page.

2.2.8 Installation Cost Data

The only cost figures identifiable for TMDE installation are those for portable carts used at each C-E site. No special fixtures or racks are used for TMDE installation, nor is there a special MOS classification to perform the installation function. Any necessary installation activity is conducted by the operating crew as a normal part of their duties. The sources of data on the cost of portable carts are the previously referenced SB 700-20, CCP-20, and manufacturers' catalogs.

2.2.9 Disposal Cost Data

2.2.9.1 MOS Classification and Cost

No particular MOS designation performs the TMDE disposal function. The TMDE, being portable, is usually removed by the operating crew from the C-E site and transported to the designated disposal area.

2.2.9.2 Disposal Costs and Assets

The assets realized from the sale of TMDE are estimated by the DA Property Disposal Office as 10% of the original cost. This figure was confirmed by a contractor who leases equipments to DoD and industry.

No data were identified for the cost of transporting TMDE to the disposal area, nor for storage costs for TMDE at the end of its life cycle.

2.2.10 Support Equipment Cost Data

At a steering committee meeting in September 1974, it was decided that the support-equipment cost element would be considered as a sunk cost for purposes of the TMDE economic analysis. This decision was premised on the fact that no support equipment is procured for TMDE other than calibration standards, which are a one-time nonrecurring cost already expended. This premise was confirmed during the data collection activity at USAMCC.

2.3 TASK 3 – EVALUATION OF DATA SURVEY RESULTS

Certain data items needed for the TMDE economic analysis were described in 2.2 as inadequate or nonidentifiable. Several means of compensating for the insufficient data, depending on the situation. were developed during Task 3. These means are 1) modification of the LCC methodology for certain cost elements; 2) the use of cost estimating relationships; and 3) the use of average rather than specific cost-element values for TMDE.

Other activities performed during Task 3 in preparation for the economic analysis included the evaluation of data and information obtained on quantifiable and nonquantifiable TMDE standardization benefits, discounted cash flow, inflation, and a TMDE phasing scenario. The phasing scenario relates to the quantity of PIL items to be added to the USACC inventory to either replace or supplement the existing non-PIL TMDE. Results of these activities are described in 2.3.1 in terms of the nine cost elements of interest in this study, and in 2.3.2 for the other cost-related activities.

2.3.1 Methodology Development for Cost Elements

2.3.1.1 Training Cost

The data identified and collected for exercising the LCC methodology to establish the TMDE cost element of training were considered adequate for that purpose. Since the data collection provided information on the quantity and location of each TMDE at the C-E sites, it will not be necessary to determine this data from the equation developed during Phase I. Further, since calibration of TMDE is considered to represent a major function, and sufficient data were identified for establishing the associated cost, it was decided to expand the LCC methodology for computing training cost. Rather than a single equation, three equations will be used: one each for calibration, operation, and repair. For each equation, the amount of training time is given by the ratio of the quantity of each TMDE to the total number of all TMDE (see 2.2). Data identified for the cost of training personnel include instructor and initial training (OJT). The equations determine costs for replacement training only.

2.3.1.1.1 Cost of Training for Calibration

The cost for calibration training can be expressed mathematically as:

$$C_{\text{Training, Calibration}} = (\text{Quantity of MOS Calibrating all TMDE}) \times \left(\frac{\text{Quantity of Each Type TMDE}}{\text{Quantity of all Types TMDE}}\right) \times (\text{Life Cycle of TMDE}) \times (\text{Turnover Rate of MOS}) \times (\text{Cost of Training One MOS for Calibration})$$

2.3.1.1.2 Cost of Training for Repair

The methodology for repair training can be expressed as:

$$C_{\text{Training, Repair}} = (\text{Quantity of all MOS Repairing TMDE}) \times \left(\frac{\text{Quantity of Each TMDE Repaired}}{\text{Quantity of all TMDE Repaired}}\right) \times (\text{Life Cycle of TMDE}) \times (\text{Turnover Rate of MOS}) \times (\text{Cost of Training One MOS for Repair})$$

2.3.1.1.3 Cost of Training for Operation

The methodology for operator training can be expressed as:

$$C_{\text{Training, Operation}} = (\text{Quantity of all MOS Operating TMDE}) \times \left(\frac{\text{Quantity of Each TMDE Operated}}{\text{Quantity of all TMDE Operated}}\right) \times \left(\frac{1}{10}\right) \times (\text{Life Cycle of TMDE}) \times (\text{Turnover Rate of MOS}) \times (\text{Cost of Training One MOS for Operation})$$

where the ratio 1/10 is an estimation of maximum time spent training for the operation of TMDE.

For all of the above equations, the total cost of training for one TMDE can be obtained by dividing the value calculated from each equation by the inventory density of that type TMDE.

2.3.1.2 Hardware Cost

Data for the hardware cost element are considered suitable for use in the methodology developed during Phase I. Since no separate data were identified for accessories or testing, the final methodology can be expressed as:

$$C_{\text{Hardware}} = (\text{Cost of TMDE}) + (\text{Cost of Software})$$

where the cost of software for each TMDE is for two copies of each manufacturer manual for calibration and maintenance at a cost of $10 per copy. The per-copy cost is an estimated average value identified during the data survey.

2.3.1.3 Personnel Cost

All data needed for determining the cost of TMDE personnel were considered to be adequately identified. Since, as just discussed, calibration is a major cost consideration for TMDE, the basic methodology developed in Phase I for personnel cost was expanded to three equations to include calibration, operation, and repair. Another modification to the methodology was to eliminate the factors for determining the total number of each TMDE attended by the MOS, and the availability of these MOS. This was done because specific data were identified for each factor, thus

permitting simplification of the equation. The complete methodology for determining personnel costs is presented in 2.3.1.3.1 through 2.3.1.3.3.

2.3.1.3.1 Cost of Repair Personnel

The methodology for establishing the cost of TMDE repair personnel can be expressed as:

$C_{\text{Personnel, Repair}}$ = (Annual Maintenance Manhours/TMDE)
x (Cost of MOS/Hour) x (Life Cycle of TMDE)
x (Productivity factor of MOS)

The annual maintenance manhours can be derived from the MTBF and MTTR data identified during Phase 2. The productivity factor of MOS was provided by the DA Comptroller at Fort Monmouth, and defined as 0.75.

2.3.1.3.2 Cost of Calibration Personnel

The methodology for determining the cost of calibration personnel can be expressed as:

$C_{\text{Personnel, Calibration}}$ = (Hours Spent Calibrating TMDE/Year)
x (Cost of MOS/Hour) x (Life Cycle of TMDE)
x (Productivity Factor)

2.3.1.3.3 Cost of Operating Personnel

The methodology for determining the cost of operating personnel can be expressed as:

$C_{\text{Personnel, Operating}}$ = (Number of Hours of Operation of TMDE/Year)
x (Cost of MOS/Hour to Operate)
x (Productivity Factor) X (Life Cycle of TMDE)

The number of hours of operation of TMDE is an estimated value described in 2.2.3.5.

2.3.1.4 Transportation Cost

Available data on TMDE transportation costs are not considered suitable for use in the methodology defined in Phase I. Documented information was unavailable for several major portions of that cost element; packaging costs, distance of shipment, and shipping rates. Accordingly it was considered practical to use CERs instead of the equations developed in Phase I for transportation costs. The CERs were prepared from cost factors provided by the DA Comptrollers Office at Fort Monmouth for first destination and second-destination transportation (maintenance). The original source of these values was the USAMC Management Information System.

The equations below account for transportation costs relating to TMDE items. Transportation costs for consumables are included in the overall cost of consumables (see 2.3.1.5).

2.3.1.4.1 First-Destination Transportation Cost

The cost of first-destination transportation can be determined as the sum of two percentages:

$$C_{\text{Transp., First Dest.}} = 0.04(0.015 \times \text{Hardware Cost of TMDE}) + 0.015(\text{Hardware Cost of TMDE})$$

where

0.04 = The Army Stock Fund (ASF) surcharge for losses of ECOM items; a percentage of the first-destination transportation cost.

0.015 = The ASF first-destination transportation percentage for ECOM items.

The above costs are nonrecurring for TMDE.

2.3.1.4.2 Maintenance Transportation Cost

The methodology for maintenance transportation cost is based on the frequency of required repair and C-level calibration and a percentage of hardware cost for losses and transportation. The CER for maintenance costs of transportation can be expressed as:

$$C_{\text{Transp., Maint.}} = [0.04(0.03 \text{ Hardware Cost of TMDE}) + 0.03(\text{Hardware Cost of TMDE})] \times [(\text{Number of Times TMDE Fails/Year}) + (\text{Number Times TMDE Calibrated/Year})] \times [(\text{Life Cycle of TMDE})]$$

where

0.04 = ASF value for surcharge for losses of ECOM items; a percentage of the maintenance transportation cost.

0.03 = Transportation cost each time a TMDE is repaired and given C-level calibration.

The number of times a TMDE fails per year can be determined from the MTBF of that TMDE and its operating time. The number of times a TMDE must be C-level calibrated per year can be determined from TB43-180.

2.3.1.5 Consumables Cost

Available information on the cost of TMDE consumables is not considered suitable for use in the methodology developed during Phase I. Therefore, CERs were developed to replace the original methodology with one based upon cost factors provided by the DA Comptrollers Office.

Cost factors on consumables from the Comptroller represent a percentage cost of the hardware. This percentage includes the cost of transportation to the maintenance facility. Typical values suggested for consumables cost are from 5% to 20% of the hardware cost per year of the life cycle. The CER for consumables can be therefore expressed as:

$$C_{\text{Consumables}} = 0.125 \text{ (Hardware cost of TMDE) x (Life Cycle of TMDE)}$$

The value of 0.125 is the average of the above-stated range. Since the estimated range may be from 5% to 20%, it is intended that a sensitivity analysis will be made on the cost of consumables to determine the effect of the variation on the output of the Phase III economic analysis. The cost of initial stockage to be determined for PIL TMDE during the analysis will be 10% of the total consumables for the entire life cycle of the TMDE.

2.3.1.6 Inventory Management Cost

The cost of inventory management is dependent on the total cost of consumables. Since inadequate data were identified for the consumables during the survey, CERs were designed to include the cost element of inventory management. Three CERs were developed: one for introducing the inventory into the supply system, another for holding the inventory in the supply system, and a third to express the total of these latter two CERs. Cost factors for the CERs were obtained from the DA Comptrollers Office at Fort Monmouth.

2.3.1.6.1 Cost for Introducing Inventory

The cost of introducing a new line item (i.e., TMDE) into the USACC inventory is $480. This information is a value based on data from the Army Maintenance Management Directorate and Maintenance Directorate and is presented in ECOMP 11-4, Volume 7. The CER for introducing an item in inventory is therefore expressed as:

$$C_{\text{Inventory Management, Introducing}} = \$480 \text{ (Number of line items Introduced into Inventory)}$$

2.3.1.6.2 Costs for Holding Inventory

The CER for holding inventory can be expressed as:

$$C_{\text{Inventory Management, Holding}} = 0.23 \text{ (Cost of Line Item) x (Life Cycle of TMDE)}$$

The above estimate of 23 percent per year is based on studies performed by the Defense Supply Agency and the Maintenance Material Directorate of USAECOM.

2.3.1.6.3 Total Cost of Inventory Management

The CER for computing the total cost of inventory management for a TMDE considers the cost of introducing and holding all the line items for that TMDE in the inventory. The CER for this can be expressed as:

$$C_{\text{Inventory Management, Total}} = \$480\ (\text{Quantity of Line Items Introduced}) + [0.23\ (\text{Cost of Line Items}) \times (\text{Life Cycle of TMDE})]$$

2.3.1.7 Documentation Cost

The data identified for the cost element of documentation were considered adequate for the TMDE economic analysis. The equation for determining documentation costs is dependent on the number of pages contained in each publication. Since a straight page-count of the quantity of pages per document for each TMDE would be time-consuming, the decision was made to use average values instead. These average values will be obtained for the Phase III economic analysis for the quantity of pages in the technical documentation associated with the three PIL and three counterpart non-PIL TMDE.

A sensitivity analysis will be conducted to determine the impact on the economic analysis of variations in the page count and cost-per-page.

The methodology for the cost element of documentation can be expressed as:

$$C_{\text{Documentation}} = (\text{Average Quantity of Pages/Publication}) \times (\text{Cost/Page}) \times (\text{Quantity of Each Type Publication})$$

where the cost per page is the estimated value for technical manuals; and the quantity of each type of publication is for technical manuals for operation, maintenance, and calibration.

2.3.1.8 Installation Cost

Data relating to TMDE installation cost are of such a nature that use of the detailed equation developed in Phase I is not warranted. The only costs incurred are for the portable carts required for each TMDE at every C-E site. Any labor required to install TMDE is minimal and performed by operating MOS at the sites. The methodology for the cost element of installation may therefore be expressed as:

$$C_{\text{Installation}} = (\text{Cost of Portable Carts per TMDE})$$

This cost is an average value based upon data from the contractors, and can be derived by using information for the three PIL and the three counterpart non-PIL TMDE.

2.3.1.9 Disposal Cost

The required data items identified for establishing TMDE disposal cost do not warrant the application of the detailed equation developed during Phase I. No major

disposal expenditures (e.g., Transportation Costs) for TMDE were identified during the survey. No costs are incurred for disposing-material, since the TMDE is shipped to the disposal location in its carrying case. Further, all disposal activity is performed by operating MOS at the site as part of their normal duties. Since the assets realized from the sale of TMDE have been estimated at 10% of the hardware acquisition cost, it is preferable to treat this value as a cost benefit by reducing the total life cycle costs determined during Phase III by this amount. The methodology for disposal can therefore be expressed as:

$$C_{Disposal} = -0.10 \text{ (Cost of TMDE Hardware)}$$

2.3.2 Other Cost-Related Factors

In addition to the cost elements just described, cost-related factors enter into the TMDE economic analysis. These include quantifiable and nonquantifiable benefits, inflation, discounting, and a phasing scenario.

2.3.2.1 Quantifiable and Nonquantifiable Benefits

Quantifiable benefits, such as the effect of standardization on production lead time, were also identified. ARINC Research noted in this study that commercial off-the-shelf PIL TMDE would not require longer production lead times than the non-PIL TMDE. Instead the contractors would have greater incentive, due to the larger volume of PIL TMDE, to improve upon production lead times. If this were the situation, better scheduling and planning by the DA and contractor could be possible, resulting in improved availability of TMDE. This quantifiable benefit, along with those resulting in potential reduction of costs (such as the need for fewer documentation types for a standard PIL TMDE) will be described in detail as part of the Phase III economic analysis. The quantifiable benefits will be analyzed using the LCC methodology with appropriate modifications. Potential quantifiable benefits to be considered are:

(1) Reduction of documentation requirements

(2) Implementation of initial provisioning

(3) Reduction in inventory management cost through elimination of different types of stockage items.

(4) Reduction of quantity of different types of consumables.

(5) Single-contractor production of TMDE and stockage in sufficient quantity to warrant the use of learning curves and to result in improved production lead times.

(6) Elimination of unnecessary TMDE items now required for spares.

Certain advantages beyond the direct cost benefits of standardizing the three PIL TMDE were identified during the data survey. A major nonquantifiable benefit is the improvement of personnel efficiency through increased exposure to one type rather than various types of TMDE. Attendant advantages might include:

(1) Improved MOS moral due to better familiarization with the equipment

(2) Enhanced safety.

Other possible benefits could be surmised, and all feasible conditions will be considered as part of the Phase III economic analysis to investigate the impact of each on the result of the analysis. The analysis of nonquantifiable benefits will be of a qualitative nature, in the form of a narrative discussion of the effects to be anticipated as a result of standardization of PIL TMDE for the Army.

2.3.2.2 Discounting and Inflation

Data were obtained from the DA Comptroller at Fort Monmouth for use in applying discounted cash flow and inflation to the Phase III economic analysis. These data are discussed below.

2.3.2.2.1 Discounting

All cost streams are to be discounted by 10% at the onset of any expenditure. This discount factor will be applied in the Phase III economic analysis to each year of the 10-year life cycle of TMDE. The present value of invested dollars will be computed by using the following equation, with the 10% discount value as a baseline for expenditures the first year:

$$P = X(1 + i)^n$$

where

P = Present values of future investments

X = Future expenditure in dollars

i = Discount rate

n = Number of years

The total life cycle cost of TMDE will be the summed value of each year of the ten years at the compounded interest rate of 10%.

2.3.2.2.2 Inflation

Anticipated inflation rates (price level indices) were provided by the DA Comptroller, Fort Monmouth, and are listed below.

Fiscal Year	Price Index
1973	90.9
1974	100.0
1975	111.0
1976	119.9
1977	128.3
1978	134.7
1979	140.6
1980	146.7
Compounded per year thereafter	3.7%

2.3.2.3 Learning Curves

Learning curves reflecting cost reductions related to purchase quantity are presented in ECOMP 11-4. The associated values should be applied during the Phase III analysis when deemed applicable.

2.3.2.4 Phasing Scenario

A program plan was obtained from USACC that demonstrates the requirements for TMDE in the force structure for fiscal years 1975 through 1984. This plan provides details on which of the non-PIL TMDE can be phased out, and the time period (fiscal year) that replacement with PIL TMDE is projected. The plan is presented by PIL items in Appendix B.

The program plan does not reflect the future requirements for an estimated 10% more TMDE per year than is currently deployed by USACC. This 10% increase, to account for TMDE attrition and new requirements, has been estimated at an equal level for fiscal years 1975 through 1984. The quantities deployed in Appendix B, plus a 10% additional quantity for each fiscal year, will be used to structure the scenario for the TMDE economic analysis.

2.4 TASK 4 – IMPLEMENTATION OF LCC METHODOLOGY

A study was made of the most suitable means of implementing the LCC estimation methodology developed for the Phase III economic analysis. Two major computerized models were reviewed for their potential application. In addition, consideration was given to the use of a computation program specifically prepared for the TMDE study. Results of the Task 4 activity are presented in 2.4.1 through 2.4.3.

2.4.1 Evaluation of Available LCC Models

2.4.1.1 Generalized Electronics Maintenance Model

The Army's Generalized Electronics Maintenance Model is designed for application to prime equipments, such as C-E end items, rather than support equipment such as TMDE. No consideration is provided in GEMM for either the operation or calibration of equipment; rather, emphasis is on the function of general maintenance. The GEMM maintenance policy assumes four standard levels of maintenance support: organizational, direct, general, and depot. That maintenance structure is not directly applicable to the AMSF concept for TMDE maintenance in the Pacific and European theaters.

To utilize GEMM properly in determining the cost of maintenance actions, data must be input on the design configurations of the equipment under analysis. It is necessary to break down the design elements into modules, components, and parts of repairable and nonrepairable characteristics, and identify the maintenance actions for checkout and fault isolation for each element. The MTBF, MTTR, cost, weight, and ordering times for each element are required as data inputs. It would be extremely time-consuming to determine this information for each TMDE item. Any inadequate or missing data items could possibly create dubious results.

GEMM determines the cost of transportation and documentation in a manner similar to that of the methodology developed in Phase I of this study. To derive

transportation costs, it is necessary to input data on the mileage to each maintenance ship, the weight of the item, and the cost per mile to ship items. For documentation, it is necessary to input the number of pages and the cost of each page for maintenance publications.

No consideration is given in GEMM for either equipment calibration or operating manuals. Further, the method in which GEMM addresses consumables is quite different from the way in which stockage is provided for TMDE. In GEMM there is initial, reorder, replacement and reissue stockage for equipment. The "secondary items concept" for TMDE does not include such stockage policies.

The above characteristics of GEMM could be changed only through extensive modifications to the software program. This effort would not be cost effective since a less complex time share computation program can be prepared to include all of the LCC methodology requirements for TMDE.

2.4.1.2 Life Cycle Cost Analysis Model

The Army's Life Cycle Cost Analysis (LOCAM) program uses simulation techniques based on reliability information from equipment and constituent components, modules, and parts to determine manpower, parts stockage, support equipment, data, and logistics support management information. Approximately 300 individual data elements must be input to exercise LOCAM. The input data include deployment factors such as number of systems, support facilities, utilization rate and attrition rate; prime equipment factors such as cost per equipment/line replaceable unit (LRU)/module, required availabilities, and construction characteristics; logistics factors such as sparing policies, supply times, transportation times, and lead times; maintenance support factors such as test equipment types, repair times, checkout times, and test program cost; and general factors such as escalation of manpower and equipment costs.

These data requirements are too extensive to consider for the economic analysis of TMDE. Further, since a large amount of the data would have to be estimated, the output of such an analysis would be questionable.

2.4.1.3 Integrated Logistics Support Models

Several Integrated Logistics Support (ILS) models programmed or developed for use on Army systems and equipment were reviewed from a summary of each found in the "Support Model Reference List" from the Applied Science Division of USAMC Maintenance Support Center, Letterkenny Army Depot. The models reviewed were the Integrated Logistics Support Evaluation Technique Model; the Army Direct Support/General Support Simulation Model; the Army Organizational Maintenance Simulation Model; the Economic Evaluation of Maintenance Support Alternative Model; and the Life-Cycle Computer Program Model.

None of these ILS models is considered suitable for application to the Phase III economic analysis. In most cases, the models were noted to be too confining; that is, they emphasized either maintenance, transportation, or some other element of ILS rather than a complete life-cycle situation. For those models that demonstrated greater versatility, the data requirements were too extensive for reasonable application to the Phase III analysis.

2.4.2 Development of Implementation Program for Phase III Economic Analysis

Since it was not possible to identify an existing cost model that could be readily adapted to the LCC methodology, it is recommended that the most appropriate approach (from a time and cost standpoint) would be to perform computations using the equations developed during Task 3. Further, since an extensive number of mathematical computations are required to evaluate the three PIL TMDE and more than 50 non-PIL TMDE, it is additionally recommended that these calculations be performed by a time-share computer program. This program can calculate the life cycle costs of TMDE using the equations developed during Task 3 for the cost elements of training, hardware, personnel, transportation, consumables, inventory management, documentation, installation, and disposal. The program can be written to apply inflation factors and discount rates to the inputs for each year's expenditures. Three classes of input data will be required:

(1) General cost data, such as MOS labor rates. These data can be stored in the file for loading into the program, eliminating the need for re-entry for each run.

(2) Specific-item data, such as TMDE cost and MTBF. These data can be input for each run as they are peculiar to each TMDE.

(3) Phasing scenario data, such as the quantity of TMDE. These data can be input at the outset of each run.

The time share program should output each year's life cycle cost for a TMDE and sum these values to provide a total life cycle cost. The program should also provide printouts for any cost element for each TMDE, on both a yearly and summed 10-year basis.

In addition to facilitating the computation efforts for life cycle costs of TMDE, the program will be useful in performing sensitivity analyses on selected data elements. The use of such a program will significantly decrease the time needed to calculate changes in life cycle costs with variations in input data.

APPENDIX A

DATA-AVAILABILITY MATRICES FOR COST ELEMENTS OF PIL AND NON-PIL TMDE

TABLE 1. DATA AVAILABILITY FOR TRAINING COSTS

	AN/USM-366V	AN/UPM-64	DU2A	LCA-6	RTA-5	SA-84N	TSA-W2	1L20	1L30	1L40	851B/8551B	851A/8551A	CP-772A/U	AN/TSM-16	AN/URM-79	AN/USM-26	AN/USM-102	AN/USM-159	AN/USM-207	CP-1026/U	CP-1033/U	CP-1049P/U	FR-67	FR-174	1020	11508	1191B	2565A	3F 112A	3734A	59	523D	5211A	5212A	5221B	5243L	602A	6H86	6152	6316A	800A	CV2002/U	CV-1921/U	MX-1637 A/U	CV-394/USA-5	525C	5251A	5253A	CV-2003B/U	CV-2003/U	CV-2003A/U	CV-3059/U	2590A	2590B	432A	AN/USM-93	AN/USM-161	AN/USM-240	TS-1[illegible]/P	411B	[illegible]
MOS classification performing A-level calibration	A												A																											A																		
MOS classification performing C-level classification	A												A																											A																		
MOS classification repairing TMDE	A												A																											A																		
MOS classification operating TMDE at the CE sites	A												A																											A																		
Cost of training one MOS for A-level calibration	B												B																											B																		
Cost of training one MOS for C-level calibration	B												B																											B																		
Cost of training one MOS for repairing TMDE	B												B																											B																		
Cost of training one MOS to operate TMDE	B												B																											B																		
Total number of MOS performing A-level calibration	C												C																											C																		
Total number of MOS performing C-level calibration	C												C																											C																		
Total number of MOS repairing TMDE	C												C																											C																		
Total number of MOS operating TMDE	C												C																											C																		
Turnover rate of MOS performing A-level calibration	B												B																											B																		
Turnover rate of MOS performing C-level calibration	B												B																											B																		
Turnover rate of MOS repairing TMDE	B												B																											B																		
Turnover rate of MOS operating TMDE	B												B																											B																		
Quantity of TMDE at each CE site	B												B																											B																		
Total number of sites with TMDE	B												B																											B																		
Life cycle of TMDE	A												A																											A																		

A - Data available, collected during Phase II

B - Data available, collected during Phase II; needs to be retrieved from documents collected

C - Data available; not collected during Phase II

TABLE 2. DATA AVAILABILITY FOR HARDWARE COSTS

	AN/USM-366V AN/UPM-84 DU2A LCA-6 RTA-5 SA-84W TSA-W2 1L20 1L30 1L40 851B/8551B 851A/8551A	CP-772A/U AN/TSM-16 AN/URM-79 AN/USM-26 AN/USM-102 AN/USM-159 AN/USM-207 CP-1026/U CP-1033/U CP-1049P/U FR-67 FR-174 1020 1150B 1191B 2565A 3F 112A 3734A 59 523D 5211A 5212A 5221B 5243L 602A 6H86 6152 6316A 800A	CV2002/U CV-1921/U MX-1637 A/U CV-394/USA-5 525C 5251A 5253A CV-2003B/U CV-2003/U CV-2003A/U CV-3059/U 2590A 2590B 432A AN/URM-98 AN/USM-161 AN/USM-260 TS-125A/P 431H 434A
The price of the TMDE	B →	B →	B →
The price of manuals obtained with the TMDE	C →	C →	C →
The price of accessories	B →	B →	B →
The expenses incurred for test and evaluation of TMDE	D →	D →	D →

A - Data available, collected during Phase II.

B - Data available, collected during Phase II; needs to be retrieved from documents collected.

C - Data available, estimated values

D - No data identified

TABLE 3. DATA AVAILABILITY FOR PERSONNEL COSTS

	AN/USM-365V AN/UPM-84 DU2A LCA-6 RTA-5 SA-64W TSA-W2 1L20 1L30 1L40 851B/8551B 851A/8551A	CP-772A/U AN/TSM-16 AN/URM-79 AN/USM-26 AN/USM-152 AN/USM-159 AN/USM-207 CP-1026/U CP-1033/U CP-1049P/U FR-67 FR-174 1020 1150B 1191B 2565A 3F 112A 3734A 59 523D 5211A 5212A 5221B 5243L 602A 6H86 6152 63116A 800A	CY2002/U CV-1921/U MX-1637 A/U CV-394/USA-5 525C 5251A 5253A CV-2003B/U CV-2003/U CV-2003A/U CV-3059/U 2590A 2590B 432A AN/USM-93 AN/USM-141 AN/USM-740 TS-125A/P 431B 434A
MOS classification performing A-level calibration	A →	A →	A →
MOS classification performing C-level calibration	A →	A →	A →
MOS classification performing repair of TMDE	A →	A →	A →
MOS classification operating TMDE	A →	A →	A →
Annual or hourly cost of MOS performing A-level calibration	B →	B →	B →
Annual or hourly cost of MOS performing C-level calibration	B →	B →	B →
Annual or hourly cost of MOS repairing TMDE	B →	B →	B →
Annual or hourly cost of MOS operating TMDE	B →	B →	B →
Time spent by each MOS (per year) performing A-level calibration on each TMDE	A →	A →	A →
Time spent by each MOS (per year) performing C-level calibration on each TMDE	A →	A →	A →
Time spent by each MOS (per year) performing repairs for each TMDE	B →	B →	B →
Time spent by each MOS (per year) operating each TMDE	C →	C →	C →
Quantity of each TMDE at each CE site	B →	B →	B →
Quantity of each TMDE maintained at each shop	B →	B →	B →
Total quantity of sites and shops	B →	B →	B →
Annual maintenance manhours of each TMDE	B →	B →	B →
MMTR of each TMDE	B →	B →	B →
MTBF of each TMDE	B →	B →	B →
Operating hours per year of each TMDE	A →	A →	A →
Operating hours per year of each CE site	A →	A →	A →
Operating hours per year of each maintenance shop	A →	A →	A →

A - Data available, collected during Phase II.

B - Data available; collected during the Phase II activity, needs to be retrieved from documents

C - Data available; estimated values

D - No data identified

TABLE 4. DATA AVAILABILITY FOR TRANSPORTATION COSTS

	AN/USM-366V	AN/UPM-84	DUZA	LCA-6	RTA-5	SA-8AW	TSA-w2	1L20	1L30	1L40	8518/8551B	851A/8551A	CP-772A/U	AN/TSM-16	AN/URM-79	AN/USM-26	AN/USM-182	AN/USM-159	AN/USM-207	CP-1026/U	CP-1033/U	CP-1049P/U	FR-67	FR-174	1020	1150B	1191B	2565A	3F 112A	3734A	59	523D	5211A	5212A	5221B	5243L	602A	6H86	6152	6316A	800A	CV2002/U	CV-1921/U	MX-1637 A/U	CV-394/USA-5	525C	5251A	5253A	CV-2003B/U	CV-2003/U	CV-2003A/U	CV-3059/U	2590A	2590B	432A	AN/URM-98	AN/USM-161	AN/USM-260	TS-125A/P	431B	432A
Location of each CE site	A	→	A	→	A	→
Distance in miles of CE site from each first shipment location (contractor)	C	→	C	→	C	→
Location of maintenance shops	A	→	A	→	A	→
Distance in miles of each CE site from the AMSF or designated maintenance shops	C	→	C	→	C	→
Weight of TMDE	B	→	B	→	B	→
Location to which TMDE is first transported (from contractor)	A	→	A	→	A	→
Number of times TMDE is sent to repair per year	B	→	B	→	B	→
MOS classification performing packaging operation for transportation	E	→	E	→	E	→
Cost per year or hour of MOS performing packaging	E	→	E	→	E	→
Cost of packaging material per shipment	E	→	E	→	E	→
Shipping cost per pound mile	E	→	E	→	E	→

A - Data available, collected during Phase II

B - Data available; collected during Phase II, needs to be retrieved from collected documents

C - Data available, needs to be calculated

D - Documented data not available; estimation used

E - No data available

TABLE 5. DATA AVAILABILITY FOR CONSUMABLES COSTS

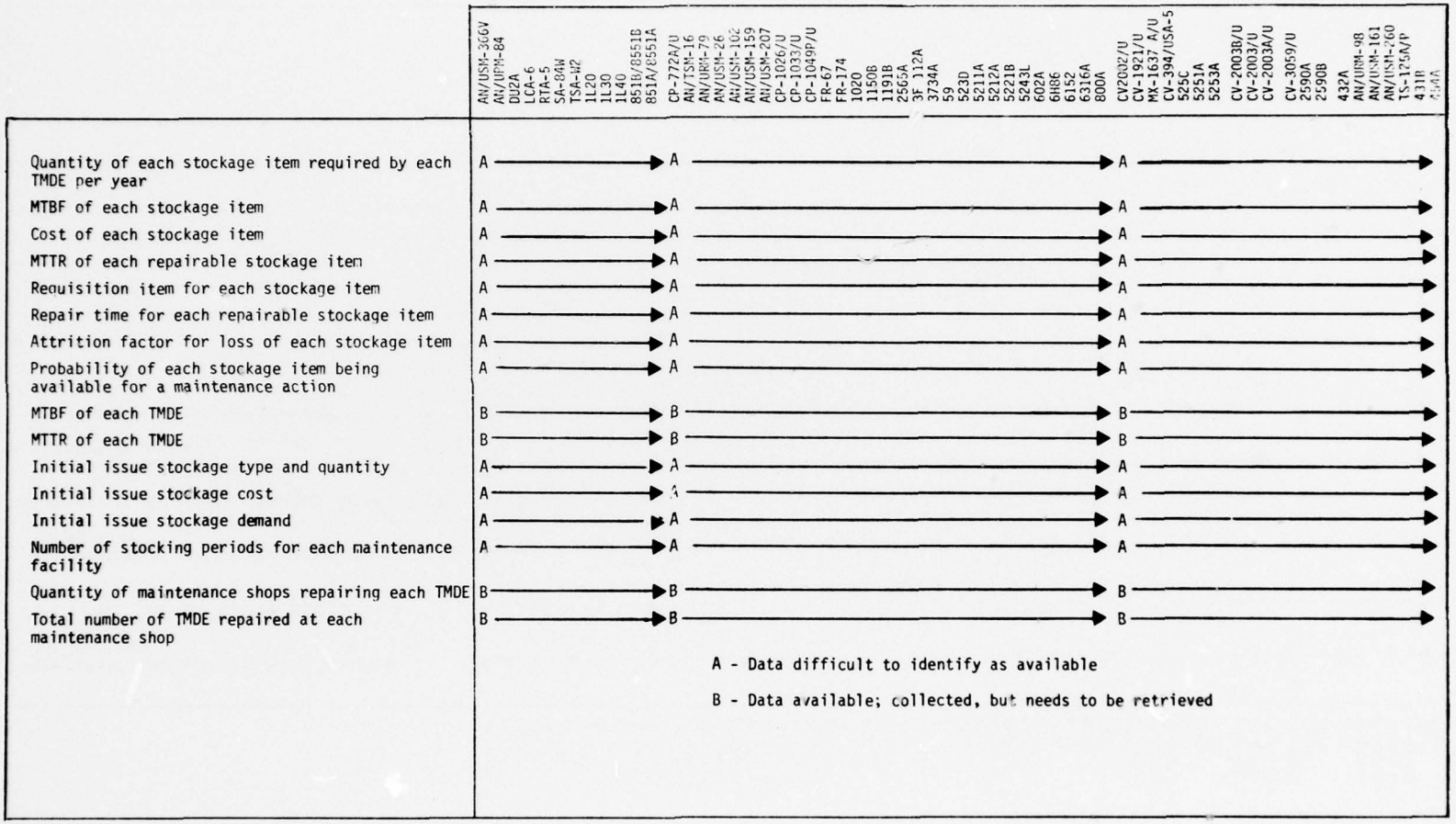

TABLE 6. DATA AVAILABILITY FOR INVENTORY MANAGEMENT COSTS

	AN/USM-366V AN/UPM-84 DU2A LCA-6 RTA-5 SA-84W TSA-W2 1L20 1L30 1L40 851B/8551B 851A/8551A CP-772A/U AN/TSM-16 AN/UPM-79 AN/USM-26 AN/USM-102 AN/USM-159 AN/USM-207 CP-1026/U CP-1033/U CP-1049P/U FR-67 FR-174 1020 1150B 1191B 2565A 3F 112A 3734A 59 523D 5211A 5212A 5221B 5243L 602A 6H86 6152 6316A 800A CV2002/U CV-1921/U MX-1637 A/U CV-394/USA-5 525C 5251A 5253A CV-2003B/U CV-2003/U CV-2003A/U CV-3059/U 2590A 2590B 432A AN/UPM-98 AN/USM-161 AN/USM-260 TS-125A/P 431B 4[illegible]
The initial stockage allocation quantity for each TMDE	A → A → A →
The cost of the initial stockage for each TMDE	A → A → A →
The quantity of reorder stockage allocated for each TMDE	A → A → A →
The cost of the reorder stockage for each TMDE	A → A → A →
The frequency of time that the reorder stockage is ordered	A → A → A →
The inventory factor for each TMDE	A → A → A →

A - Data difficult to identify

TABLE 7. DATA AVAILABILITY FOR DOCUMENTATION COSTS

	AN/USM-366V, AN/UPM-84, DU2A, LCA-6, RTA-5, SA-848, TSA-W2, 1L20, 1L30, 1L40, 851B/8551B, 851A/8551A	CP-772A/U, AN/TSM-16, AN/URM-79, AN/USM-26, AN/USM-103, AN/USM-159, AN/USM-207, CP-1026/U, CP-1033/U, CP-1049P/U, FR-67, FR-174, 1020, 11508, 1191B, 2565A, 3F 1112A, 3734A, 59, 523D, 5211A, 5212A, 5221B, 5243L, 602A, 6H86, 6152, 6316A, 800A	CV2002/U, CV-1921/U, MX-1637 A/U, CV-394/USA-5, 525C, 5251A, 5253A, CV-2003B/U, CV-2003/U, CV-2003A/U, CV-3059/U, 2590A, 2590B, 432A, AN/URM-98, AN/USM-161, AN/USM-260, TS-1?5A/U, 431B, 434A
The type of documentation existent for each TMDE for calibration	A →	A →	A →
The type of documentation existent for each TMDE for operation	A →	A →	A →
The type of documentation existent for each TMDE for maintenance	A →	A →	A →
The type of documentation existent for each TMDE for spares (RPSTL)	B →	B →	B →
The number of pages present in each document for each TMDE	B →	B →	B →
The cost per page of each document	A →	A →	A →

A - Data available and collected

B - Data available, needs to be retrieved

TABLE 8. DATA AVAILABILITY FOR INSTALLATION COSTS

	AN/USM-366V AN/UPM-84 DU2A LCA-6 RTA-5 SA-84W TSA-W2 1L20 1L30 1L40 851B/8551B 851A/8551A	CP-772A/U AN/TSM-16 AN/URM-79 AN/USM-26 AN/USM-102 AN/USM-159 AN/USM-207 CP-1026/U CP-1033/U CP-1049P/U FR-67 FR-174 1020 1150B 1191B 2565A 3F 112A 3734A 59 523D 5211A 5212A 5221B 5243L 602A 6N86 6152 6316A 800A	CV2002/U CV-1921/U MX-1637 A/U CV-394/USA-5 525C 5251A 5253A CV-2003B/U CV-2003/U CV-2003A/U CV-3059/U 2590A 2590B 432A AN/URM-98 AN/USM-161 AN/USM-260 TS-125A/P 431B 434A
Cost of fixtures to install each TMDE	A →	A →	A →
Cost of mobile carts to move TMDE within each site	B →	B →	B →
MOS classification installing TMDE in racks	A →	A →	A →
Annual cost of MOS installing TMDE in racks	A →	A →	A →
Time spent by MOS installing TMDE	A →	A →	A →

A - No data available

B - Data identified, needs to be retrieved

TABLE 9. DATA AVAILABILITY FOR DISPOSAL COSTS

	AN/USM-366V AN/UPM-84 DU2A LCA-6 RTA-5 SA-94W TSA-W2 1L20 1L30 1L40 851B/8551B 851A/8551A	CP-772A/U AN/TSM-16 AN/URM-79 AN/USM-26 AN/USM-102 AN/USM-159 AN/USM-207 CP-1026/U CP-1033/U CP-1049P/U FR-67 FR-174 1020 1150B 1191B 2565A 3F 112A 3734A 59 523D 5211A 5212A 5221B 5243L 602A 6H86 6152 6316A 800A	CV2002/U CV-1921/U MX-1637 A/U CV-394/USA-5 525C 5251A 5253A CV-2003B/U CV-2003/U CV-2003A/U CV-3059/U 2590A 2590B 432A AN/UXM-9R AN/UXM-161 AN/USM-260 TS-125A/U 431[illegible] 4[illegible]
Time spent by MOS to remove TMDE from operation	A →	A →	A →
Annual or hourly cost of MOS removing TMDE	A →	A →	A →
Expense incurred in transporting TMDE from site to disposal area	A →	A →	A →
Expense incurred to store TMDE in preparation of disposal action	A →	A →	A →
Assets realized from the sale of TMDE	B →	B →	B →

A - No data available

B - Data identified, estimated values

APPENDIX B

TMDE PHASING MATRICES

The matrices presented in this appendix show the current density in USACC of the three selected PIL TMDE and the non-PIL TMDE they can replace. Also shown, as projected needs, are the quantities of the specific types of PIL TMDE that can be phased into the USACC inventory per fiscal year. This quantity also represents the non-PIL TMDE that are phased out and replaced by PIL TMDE. The values shown in the matrices and an additional 10% quarterly (not shown) are recommended for use in the Phase III economic analysis. The 10% factor accounts for projected new requirements of USACC and any attrition losses of the TMDE.

The phasing data presented allow for complete replacement of non-PIL TMDE by PIL TMDE over a 10 year period. The replacement sequence was defined by USACC personnel.

TMDE PHASING PLAN (Sheet 1 of 5)

PIL TMDE	Current Density (units)	Non-PIL TMDE	Current Density (units)	Projected Needs (units) by Fiscal Year									
				75	76	77	78	79	80	81	82	83	84
AN/USM-366(V)1 (491)	26	AN/UPM-84	3			3							
		DU-2A	4		4								
		LCA-6	1	1									
		RTA-5	1	1									
		SA-84W	1	1									
		TSA-W2	1	1									
		IL20	2			2							
		IL30	1		1								
		IL40	25					7	5	5	4	2	2
		851A/8551A	2			2							
		851B/8551B	12			1	10	1					
		Total Req	53										
		Total to be Procured by FY		(4)	5	8	10	8	5	5	4	2	2

TMDE PHASING PLAN (Sheet 2 of 5)

PIL TMDE	Current Density (units)	Non-PIL TMDE	Current Density (units)	Projected Needs (units) by Fiscal Year									
				75	76	77	78	79	80	81	82	83	84
CP-772A/U (5245L)	283	AN/TSM-16	136		27	75	34						
		AN/URM-79	13		13								
		AN/USM-26	2	2									
		AN/USM-102	7	6	1								
		AN/USM-159	47				47						
		AN/USM-207	194					28	50	50	25	25	16
		CP-1026/U	1	1									
		CP-1033/U	3	3									
		CP-1049P/U	11				11						
		FR-67	6	6									
		FR-174	9		9								
		1020	1	1									
		1150B	1	1									
		1191B	1	1									
		2565A	16					16					
		3F112A	1	1									

TMDE PHASING PLAN (Sheet 3 of 5)

PIL TMDE	Current Density (units)	Non-PIL TMDE	Current Density (units)	Projected Needs (units) by Fiscal Year									
				75	76	77	78	79	80	81	82	83	84
CP-772A/U (5245L) (Continued)		3734A	2	2									
		59	3	3									
		524C	5	5									
		5211A	7				7						
		5212A	3	3									
		5221B	16				1	15					
		5243L	6	6									
		602A	2	2									
		6H86	3	3									
		6152	3	3									
		6316A	16					16					
		800A	1	1									
		Total Req	516										
		Total to be Procured by FY		50	50	75	100	75	50	50	25	25	16

TMDE PHASING PLAN (Sheet 4 of 5)

PIL TMDE	Current Density (units)	Non-PIL TMDE	Current Density (units)	Projected Needs (units) by Fiscal Year									
				75	76	77	78	79	80	81	82	83	84
CV-2002/U (5253B)	158	CV-1921/U	38			15	20	3					
		MX-1637A/U	13	3	10								
		CV-394/USA-5	4	4									
		525C	3	3									
		5251A	9					9					
		5253A	1					1					
		Total Req	68										
		Total to be Procured by FY		10	10	15	20	13					
CV-2003B/U (5254C)	1	CV-2003/U	22	12	10								
		CV-2003A/U	1		1								
		Total Req	23										
		Total to be Procured by FY		12	11								

TMDE PHASING PLAN (Sheet 5 of 5)

PIL TMDE	Current Density (units)	Non-PIL TMDE	Current Density (units)	Projected Needs (units) by Fiscal Year									
				75	76	77	78	79	80	81	82	83	84
CV-3059/U (5255A)	85	2590A	1	1									
		2590B	40	11	15	14							
		Total Req	41										
		Total to be Procured by FY		12	15	14							
432A	23	AN/URM-98	109	1	30	45	33						
		AN/USM-161	17	17									
		AN/USM-260	66				27	39					
		TS-125A/P	2	2									
		431B	55					6	30	19			
		454A	49							11	30	8	
		Total Req	298										
		Total to be Procured by FY		20	30	45	60	45	30	30	30	8	

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